MATH'S NOTES

BY IRWIN MATH,* WA2NDM

Optical Isolation

When the ultimate electrical isolation from input to output in any transmission scheme is required, it is hard to beat a fiber optic link. The use of a beam of light, traveling through a glass (or plastic) fiber, totally isolates one end of the link from the other. The glass and plastic that fiber optic cable is made of is an excellent insulator and offers thousands of volts (per inch) of isolation. "Fine," you say, "But what if one needs isolation but cannot afford the cost or space required by such a link? Or, what if the space required is simply not there?" The answer is the optical isolator and we will devote this month investigating a few of the many applications of this low-cost alternative.

The basic optical isolator consists of a light source and a detector. Both are in the same small IC package, however, and are isolated from each other electrically. The only "connection" is a short space between the two that allows light from the LED to reach the photosensitive area of the detector. *Figure 1* shows the construction of a typical optical-isolator or "opto-isolator" as they are sometimes called.

The LED used is very similar to a standard indicator LED but usually operates in the infra-red portion of the spectrum as that is where the photodiode is most sensitive. The photodiode is also conventional and almost always is teamed with another device to amplify its feeble current. Our examples show transistors but opto-isolators are available with Darlington configurations for higher current, logic gates for various digital interfaces, and even SCRs (silicon-controlled rectifiers) and triacs for AC line-switching purposes. Even the so-called "solid-state relay" is often just an opto-isolator with a power MOSFET output stage. What is really important however, as we have already said, is that there is no electrical connection between the LED and the rest of the circuit. This is where the isolation comes in. In fact, the breakdown voltage between the two is usually on the order of 1,500 to 2,500 volts for general purpose devices to as high as 5,000 volts for premium units.

Interfacing to LEDs is not that difficult. If you are using the unit as a simple switch, for example, the circuit of *Figure 2* will suffice. Here we have used the Hewlett-Packard HCPL-4502 as it is fairly common and usually costs less than $2 each in single quantities from most major electronic parts distributors. A host of other similar devices will do as well, and depending on where you purchase them, cost should also be very moderate. Finally, before attempt-

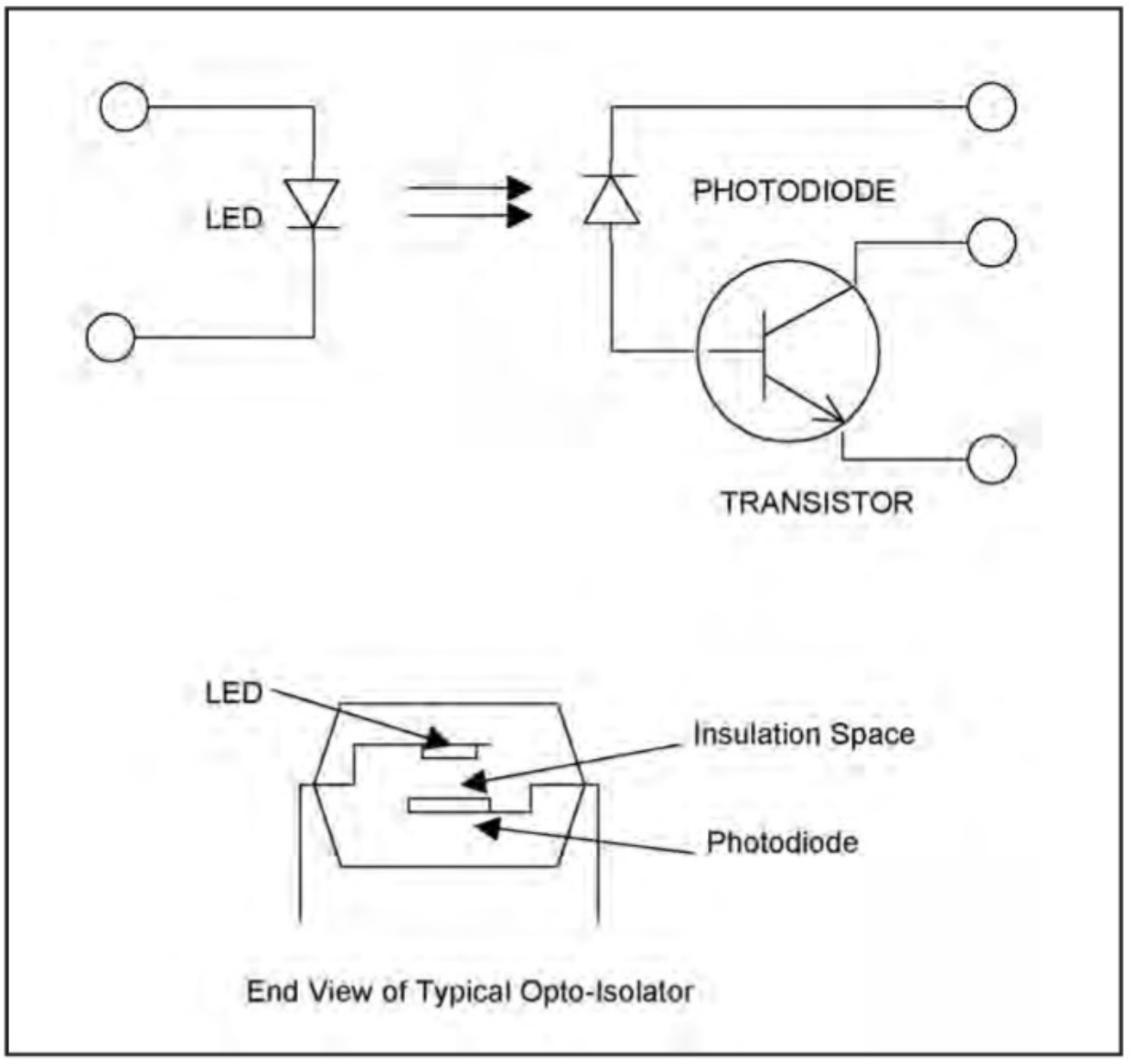

Figure 1. Construction of a typical Opto-Isolator

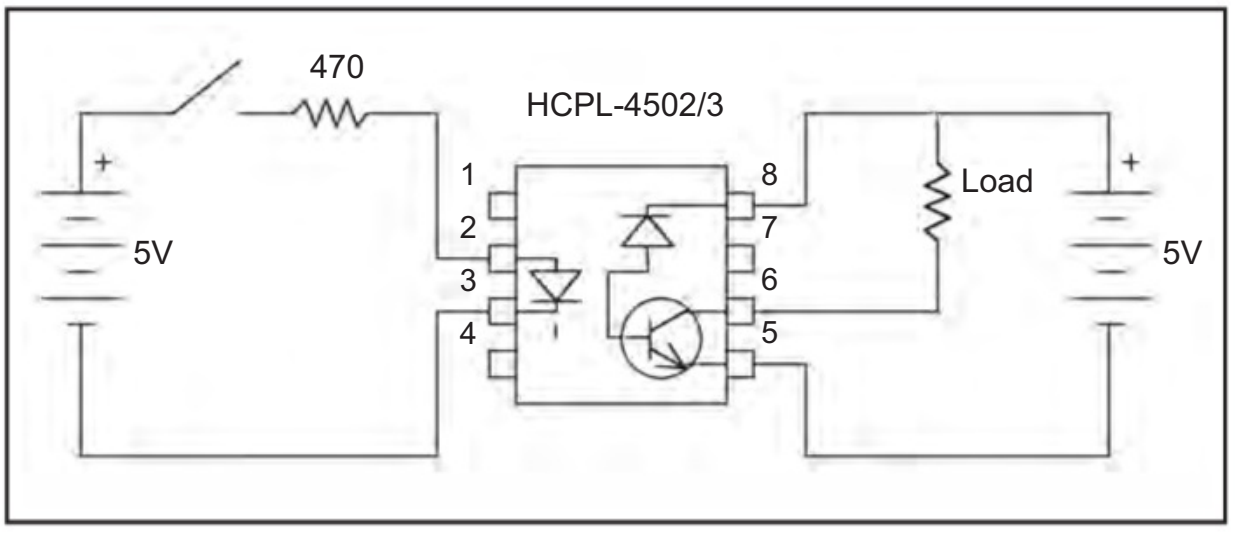

Figure 2. Opto-Isolator used as a switch

*c/o CQ magazine

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ing to use them, be sure you check the pin connections as others may be different.

In operation, closing the switch allows roughly 8 milliamps to flow through the LED in our example. This light level falling on the photodiode is enough to allow it to pass enough current to saturate the output transistor and allow maximum current to flow through the load. For larger input voltages, simply increase the value of the 470-ohm resistor accordingly. LED current, however, should be limited to a maximum of 15 milliamps or so to prevent damage, but check the rating of the device you are planning to use. For the HCPL-4502, the maximum average current safely allowed by the output transistor is 8 mA so be sure to not exceed this value. If you must switch to higher current, you will have to choose a different opto-isolator or add an external transistor.

Figure 3 is a circuit that allows conventional TTL (transistor-transistor logic) signals to be isolated from each other. Although not the absolute simplest, it is adequate to illustrate how this type of interface can be configured. Operation is as follows: A TTL low input causes the 7405 output collector to not conduct. This allows the 470-ohm resistor to pass enough current to light the LED in the opto-isolator. The opto-isolator output transistor now conducts, producing a "logic 0" input to the 7404 inverter. This forces its output high, which, in turn forces the output of the second stage low. When the input goes high, everything reverses. Remember, the 5-volt supplies on either side of the opto-isolator need not be the same nor connected to each other. The two 7404 inverters are used to produce true TTL signals in phase with the input. You should notice, however, that the direct output of the opto-isolator is also of the correct phase and "practically TTL" as well. For those who plan to actually build this circuit, maximum speed will be in the neighborhood of 500 kHz (1 Mb/s). For higher speeds, you will need a different opto-isolator.

Figure 4 shows a way to level-shift a TTL signal when something other than 0 and 5 volts is required. In this circuit, the opto-isolator output transistor is used as a "pass device" and negative 12-volt pulses result, as shown. Almost any desired

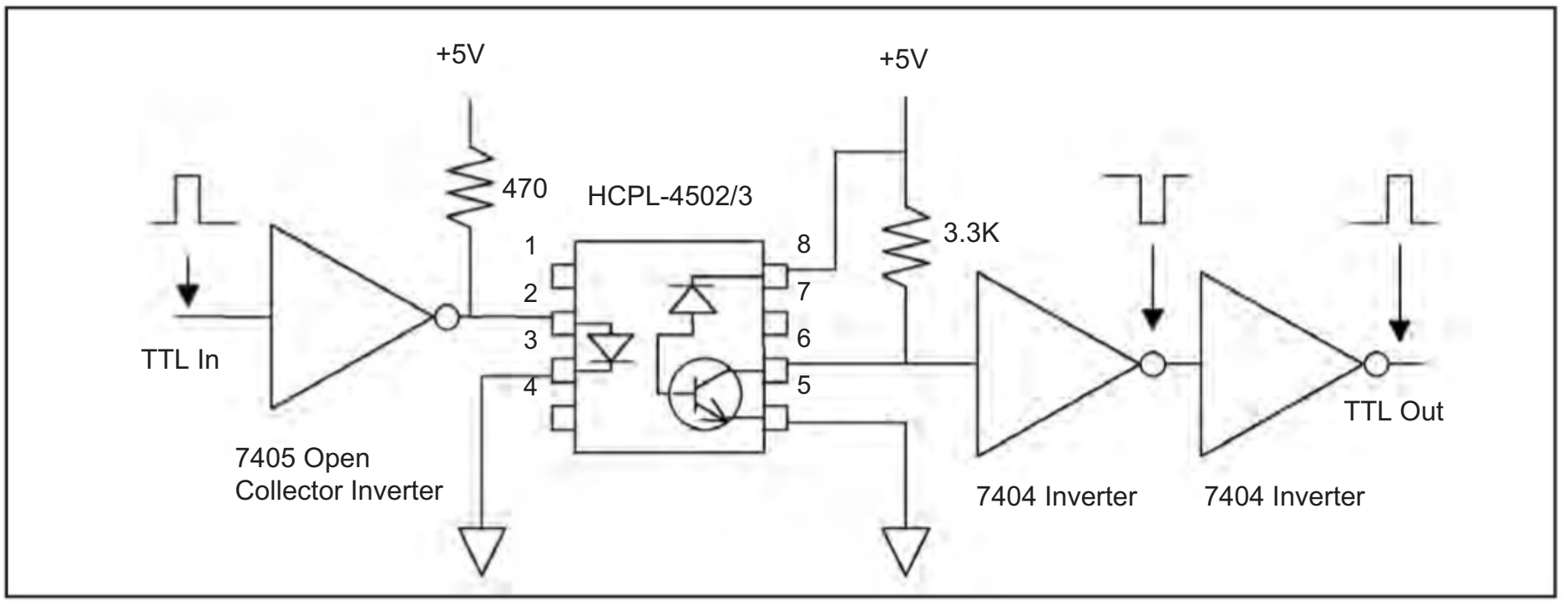

Figure 3. Simple TTL isolation system

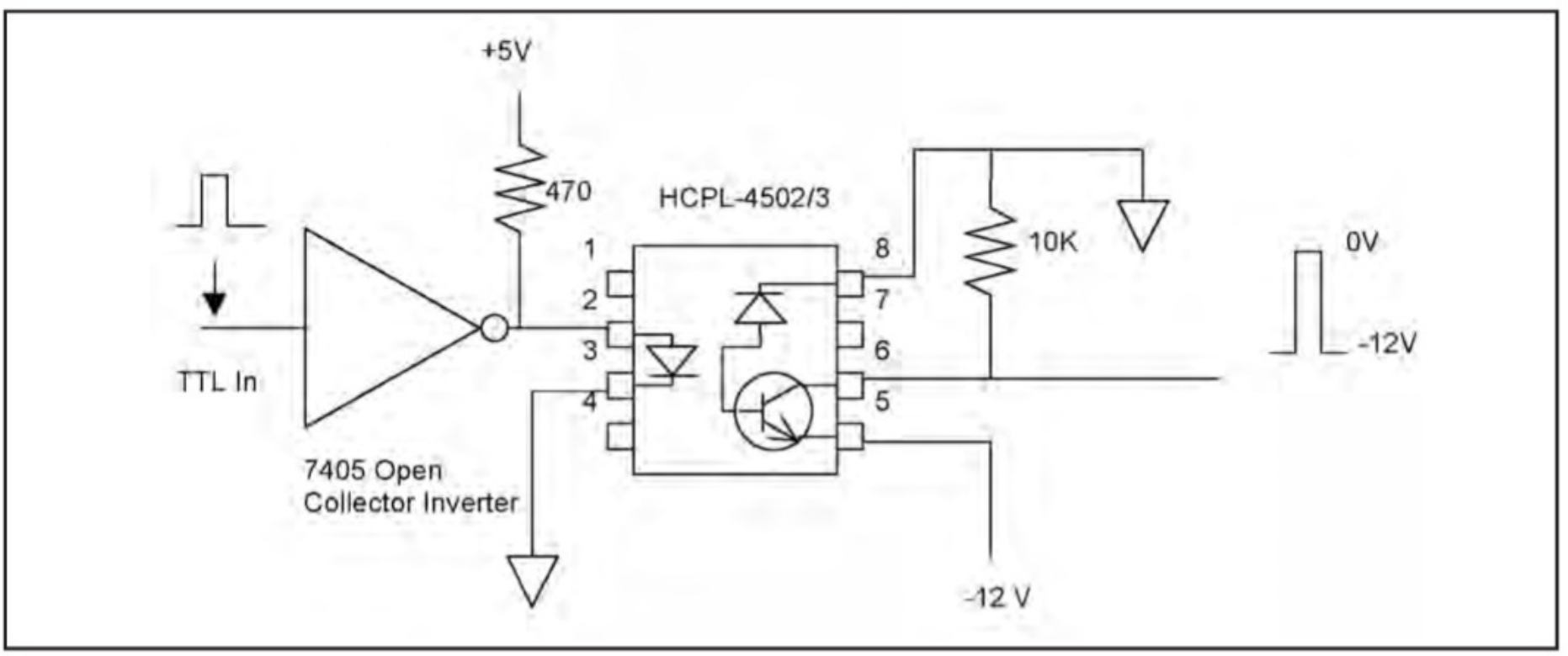

Figure 4. Simple level shifted and isolated system

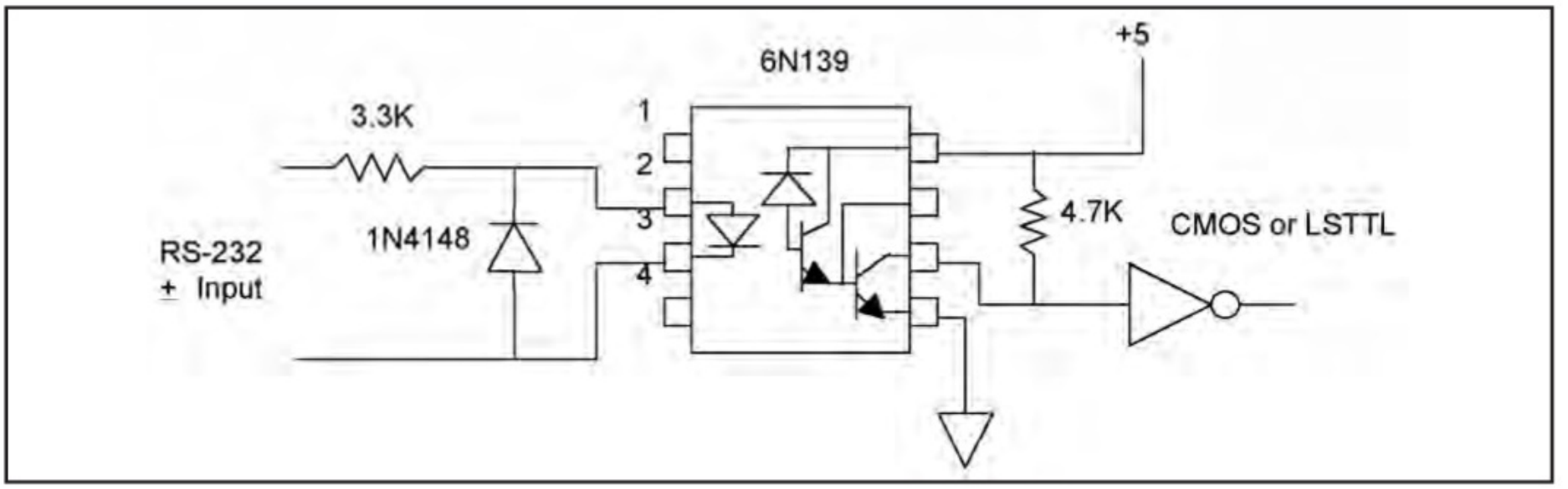

Figure 5. Isolated RS-232 input circuit

output level, positive or negative, can be obtained with this scheme by proper orientation of the component values and voltages.

Our final circuit is one that should be of interest to many experimenters. It is a way to isolate a typical RS-232 data signal while converting it to TTL for further processing. *Figure 5* shows this circuit. Here, a small signal diode is connected across the RS-232 input to block the negative excursion of the RS-232 signal. Otherwise, operation is the same as in the prior examples. The use of the 6N139 in this case allows proper operation over the entire ±3- to ±25-volt range of conventional RS-232.

– 73, Irwin, WA2NDM

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Correcting an Error …

An eagle-eyed reader caught an error in Figure 2 of the August "Math's Notes" column as well as in the text describing it.

Dear *CQ* magazine,

There is a fairly serious error in the "Math's Notes" article in the August 2019 issue on page 48. Figure 2 has an error in the line for "HOT AND NEUTRAL REVERSED." The chart says C will NOT be lit and A will be lit; both are WRONG. A will be OFF, B will be ON [correctly stated in the article's Figure 2], and C will be OFF. The chart is correct for normal, ALL CONNECTIONS OK, GROUND MISSING, and NO POWER AT ALL.

The chart has no listing for NEUTRAL OPEN; for this condition, light A will be ON, light C will be OFF, and light B will be ON, but DIM.

Because of its internal wiring, if the HOT and NEUTRAL are reversed in the E.F. Johnson Invader 2000, the breaker for the outlet may trip and there will be a shower of sparks when the transmitter is plugged in if it is wired for 120 VAC rather than 240 VAC.

– 73, George J. Misic, KE8RN

WA2NDM replies:

KE8RN is correct. I apologize for the error. The text should read as follows:

When connected to an outlet with proper wiring lamps A and C will light. Lamp B will not light since the voltage across it is virtually 0. If the ground connection is not there however, then there will be no path for lamps A or B to light and only lamp C will light. If the "hot" lead and neutral lead are reversed but ground is present then both B and C will light. With no power at all none of the lights will light.

A corrected diagram for Figure 2 is printed below.

Basic Light Indications	B	A	C
All Connections all OK	○	●	●
Ground Missing	○	○	●
"Hot" and Neutral Reversed	●	○	●
No Power at all	○	○	○